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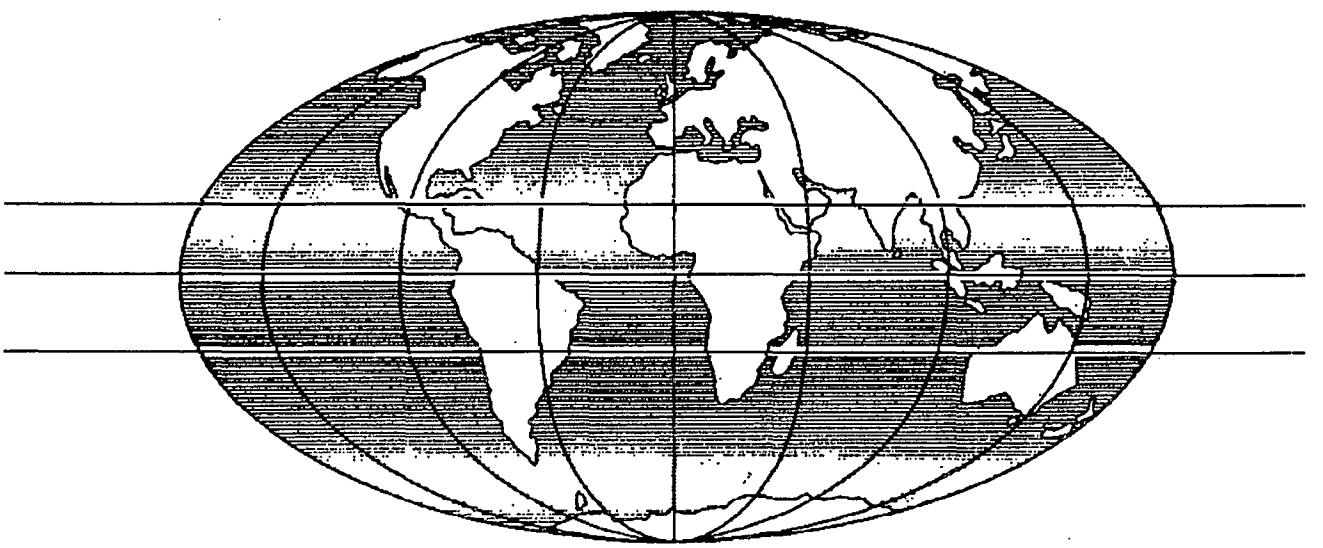

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The application of road safety countermeasures in developing countries

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Introduction. Since 1972 the Overseas Unit of the U.K. Transport and Road Research Laboratory (TRRL) has been engaged in a programme of research on road accidents in developing countries. Results[1,2] to date indicate that fatality rates (per licensed vehicle) are high in comparison with those in developed countries, and whereas in Europe and North America the situation is generally improving, many developing countries have experienced a worsening situation, particularly over the last five years. A preliminary study in six countries has indicated that road accidents cost on average almost 1 per cent of these countries' annual gross national product[3]. The most appropriate methodology for costing road accidents in developing countries is currently the subject of a review funded by the World Bank, but it is clear that road accidents are utilising scarce financial resources that the countries themselves can ill afford.

A paper presented at the PTRC Summer Annual Meeting in 1979[4] emphasised that little can be done effectively to improve the road accident situation until the problem itself has been clearly defined. In order to do this, and thereby to gain an understanding of the factors involved in road accidents, it was stressed that it was necessary to examine the accident situation at several different levels, from the broad perspective of the national scene to the detail of the individual accident. In this paper the problems of applying road safety countermeasures in developing countries are examined.

Over the past 50 years developed countries have built up considerable experience in road safety theory and practice, including a fairly substantial body of research data. Potentially, this experience should be of value to developing countries in assessing priorities in their own road safety programmes. However, before attempting to apply research findings from, say, Great Britain or the U.S. to Third World countries, a number of general reservations should be made and these will be considered in subsequent sections of this paper:

(*1*) The nature of the problem in developing countries may be considerably different from that in Europe or North America.

(*2*) Countermeasures that are effective in developed countries may be ineffective in developing countries, and *vice versa*.

(*3*) Although there has been extensive research into the effectiveness of countermeasures in developed countries, the results of this research may be less definitive than might be desired.

(*4*) Countermeasures that are appropriate in developed countries may, for financial or other reasons, be inappropriate in Third World countries.

The nature of the problem

Broad categorisations of accident and casualty types are basic indicators of the general strategy required in tackling a country's road safety problem. In Great Britain[5], for example, three-quarters of accidents occur in built-up areas, and of these accidents two-thirds occur at or within 20 yards of a junction. Also, nearly 60 per cent of those killed on all types of road in Great Britain are either pedestrians or riders of two-wheeled vehicles.

Such patterns of accidents will clearly vary from country to country and Table 1 shows that, for classes of road user killed, these differences can be considerable. Wide differences between countries can also exist in the urban/rural split; for example, whereas 44 per cent of fatalities in Great Britain occurred on roads in non-built up areas in 1977, the equivalent figure for West Malaysia was 61 per cent, with a further 26 per cent of fatalities occurring in villages and only 12 per cent occurring in towns[6]. With this situation, it would appear appropriate to devote more resources to rural accidents in West Malaysia than would be the case in Great Britain.

An analysis[7] of one complete year's accident records from Kenya showed that over 16 per cent of all road casualties were occupants of commercial vehicles. The equivalent value for Great Britain is of the order of 2·5 per cent. In many developing countries, commercial vehicles are used to transport people to and from places of work (see Fig 1), and greater attention than in, say, Great Britain to accidents involving commercial vehicles might be needed.

A comparison of accidents taking place in selected towns and cities in developed and developing countries reveals interesting differences[8]. In the towns studied in Great Britain 20 per cent of all accidents occurred within the central area of each town. In Nairobi and Mombasa (Kenya), Surabaya (Indonesia) and Kingston (Jamaica),

Table I. Percentage of fatalities by road user class

	Year	Pedestrians	Cyclists	Motorcyclists and scooterists	Drivers and passengers	Total
W. Malaysia	1977	23	15	31	30	100
Indonesia	1977	20	2	34	44	100
Nigeria		35	3	20	42	100
Guyana	1977	45	13	10	28	100
Jamaica	1977	45	5	14	36	100
Kenya	1972	45	9	2	40	100
Swaziland	1978	55	5	0	40	100
Zambia	1977	40	8	3	49	100
Ethiopia	1976	84	1	1	13	100
(Hong Kong	1976	70	4	7	19	100)
United Kingdom	1978	35	5	17	43	100

equivalent values ranged from 24 to almost 60 per cent. This larger proportion of accidents in central areas of Third World cities is probably a function of land-use and social activity; developing countries tend to have the large majority of shops, businesses and even industry concentrated in the centre of their major cities, with less activity on the periphery than is the case in Great Britain.

The proportions of casualties occurring in urban areas to the various classes of road user also revealed important differences. In most of the Third World cities studied, the proportion of pedestrian casualties was higher than in Great Britain. It is worth noting in turn that the proportion of pedestrian casualties in Great Britain is itself high in comparison with other countries of Western Europe. Greater efforts should perhaps be devoted in Third World cities to dealing with urban pedestrian accidents than in Europe.

In many Third World countries a major road safety problem may be present that does not exist at all in Western Europe and North America—accidents involving paratransit forms of public transport, for example. Thus in Surabaya, the second city of Indonesia, 17 per cent of all casualties were drivers of passengers of *betjaks* (cycle rickshaw). According to surveys carried out in Surabaya there were, in 1974, over 70 000 of these vehicles operating in the city. The drivers and passengers of these vehicles are often placed in a vulnerable position, not only because the vehicles provide little protection, but also because the operators frequently ignore all traffic rules and regulations. This type of problem is clearly non-existent in Europe and remedial measures adopted from developed countries may do little to deal with this situation.

An analysis of the vehicles involved in urban road accidents again illustrates important differences between towns and cities in Great Britain and six Third World cities. In Great Britain almost two-thirds of all vehicles involved were cars and taxis. Not surprisingly, in the Third World cities, where car ownership levels are much lower, the proportion of accidents involving cars was much less. In Surabaya (Indonesia) and Bangalore (India), the proportion was little over 10 per cent, for example. Correspondingly, the proportions of accidents involving commercial vehicles and buses which are often overloaded (see Fig 2) were much greater than in Great Britain. Thus in the major cities of India, for example, buses are involved in 20–25 per cent of all personal-injury accidents, the equivalent figure for the U.K. being under 5 per cent. The Calcutta State Transport Corporation has over 0·80 fatalities per million bus-kilometres operated, whilst the equivalent U.K. urban bus fatality rate is under 0·1.

These various examples of major differences in accident pattern between countries have been used to emphasise the point that the order of priorities in road safety programmes in developing countries could, more often than not, be very different from that in developed countries. This may require a change of approach and even attitude on the part of overseas advisors.

Fig 1. An open lorry used to transport men to places of work, Indonesia.

Fig 2. An overloaded bus in India

Table II. Non-observance of the red signal

City		Number of drivers who had a free choice of stopping or not stopping at red signal	Number of drivers choosing not to stop at red signal	Percentage of drivers choosing not to stop at red signal
Ankara (2 sites)	1974	101	36	35·6
Bangkok (9 sites)	1975	754	391	52·0
Nairobi (2 sites)	1975	203	101	50·0
Nairobi (10 sites)	1977	3045	210	7·0
Surabaya (6 sites)	1975	253	92	36·0
Surabaya (6 sites)	1976	396	130	48·8
Central London (11 sites)	1977	364	22	6·0
Reading Area (19 sites)	1977	726	30	4·1

The relative effectiveness of countermeasures in developed and developing countries

The effectiveness of a road safety countermeasure can, in some instances, be largely dependent upon local conditions, even within a country; and clearly there are major differences, either physical or cultural, between conditions in developed and developing countries. For example, it has been observed that drivers in developed countries are more likely to obey traffic control and safety devices than those in developing countries (see below). It is therefore possible that countermeasures such as 'ghost islands' protecting right-turners at T-junctions, which have proved highly cost-effective in developed countries, might be less effective in Third World countries. On the other hand some countermeasures, such as the wearing of seatbelts, should perhaps be effective in both types of country.

Two measures commonly used for controlling road users and improving their safety are traffic signals and pedestrian crossings. Preliminary studies have observed the behaviour of drivers at traffic signals and pedestrian crossings in selected cities in developing countries and comparisons made with results from Great Britain. For example, driver behaviour at 'Zebra-type' crossings was observed in five Third World cities and compared with behaviour at selected Zebra crossings in Reading and London. It was mandatory for drivers to stop for pedestrians on the crossing in all cities studied. It was found that the average proportion of drivers stopping in four of the Third World cities ranged from 10 to 17 per cent, whilst in Surabaya the percentage was well under 1 per cent. The equivalent values in Reading and London were 72 and 40 per cent respectively.

Observations were also made at signal-controlled junctions in the same cities and the proportions of drivers (presented with a free choice) stopping at the red signal were recorded. Results are given in Table II. It can be seen that the percentage of drivers choosing not to stop at the red signal in the Third World cities was greater than in Reading and London. Studies were carried out in Nairobi in 1975 and 1977; the results for 1977 showed a marked improvement over the 1975 value. This surprising result may be due to the fact that the number of signals in the city increased from 3 to over 20 between 1975 and 1977. Having more signals (and having them set correctly) may have brought about the observed improvement in driver behaviour. It should be noted, however, that in Bangkok, Ankara and Surabaya many junctions were signal-controlled, but behaviour was still poor.

Table IIIa. A 'before-and-after' analysis of the introduction of crash-helmet legislation in Anambra State, Nigeria (from Asogwa[9])

Period	No. registered motorcycles	No. injured	No. death
Before edict (June 1974–May 1976)	5303	70	5
After edict (June 1976–May 1978)	7071	145	18

Table IIIb. Results of a roadside survey

Wear of helmet	Number	Percentage
Worn correctly	134	60·9
Worn incorrectly	86	39·1
Total	220	100

Table III presents the results of what is perhaps the first published 'before-and-after' study of a road accident countermeasure to have been reported from a developing country. The study is an investigation by Asogwa into the effectiveness of the motorcycle helmet legislation introduced in Anambra State, Nigeria, in 1976[9]. Table III appears to show that there was a sharp rise in motorcyclist injuries and fatalities in the 'after' period. There were apparently no changes in the accident recording procedure in the 'after' period. Ideally, a number of 'control' comparisons could have been made to confirm this rather surprising result; for example, a comparison with the 'before' and 'after' accident frequencies for other road user groups in Anambra State and a comparison with motorcycle accidents in both periods in a neighbouring State that had not introduced the legislation. The International Road Federation's *World Road Statistics* suggest that for all Nigeria there were the following increases for the period 1976–77 compared with 1974–75: all road accident fatalities, 41 per cent; all injuries, 50 per cent; injury accidents, 30 per cent; and 'four-plus' wheeled vehicles, 25 per cent. If these figures are representative of Anambra State, it would suggest that there remains an increase in motorcycle accidents over and above the expected increase. Asogwa attributes this to the large percentage of riders and passengers (40 per cent in a roadside sample of 220) who wore the helmet incorrectly, i.e. either loosely secured or not secured at all. He also argues that the helmets could have given the riders a false sense of security, leading to greater risk-taking. It would appear that the discomfort caused by wearing the helmet in a high temperature and humidity was a major reason for the chinstraps not being fastened properly.

Thus, in at least the cases of traffic signals, pedestrian crossings and crash helmets, there is evidence of road safety countermeasures being less effective in developing countries compared with developed countries (although increased enforcement could perhaps have improved the performance of these measures). There is reason to believe that the converse effect could happen. For example, it may well be possible that remedial measures such as driver education or propaganda, whose benefits have been found difficulty to identify and quantify in Europe and the U.S., could be far more effective in developing countries where the existing standard of road-user knowledge is much lower.

Cultural differences must also be considered when assessing the potential for road accident reduction in developed and developing countries. The problems associated with drinking and driving are probably more dependent upon local cultural and social conditions than any other factor in road safety. The Road Safety Act 1967 introduced the Breath Test to the U.K. and Beaumont and Newby[10] have concluded that the Act brought about the biggest reduction in road casualties to have occurred in recent years. Little is known about the contribution of alcohol to road accidents in developing countries. In some, the Caribbean countries for example, it may be more important than in the U.K.; in others, Muslim countries for example, it may far less important.

Uncertainties in the effectiveness of countermeasures used in developed countries

Whilst the benefits of certain countermeasures in developed countries seem fairly well established (e.g. seat belts), there are numerous other potential remedial measures whose benefits remain to be fully proven. There are several reasons for this, but an important factor has been that, in the past, the need for evaluation was not so widely appreciated as now. Thus safety measures have frequently been introduced on the basis of 'commonsense' or scientific/engineering principles, without any attempt at evaluating their effectiveness in terms of lives saved or numbers of accidents reduced.

Where evaluation has been attempted, problems of interpretation of the results have frequently arisen. These largely derive from the 'multi-causal and probabilistic' nature of accidents. The typical accident is not the result of a single cause but is the result of a combination of causes, and there is always a considerable element of chance whether a particular combination of causes will in fact result in an accident. Without carefully-designed studies it is difficult to be certain that apparent benefits are due to the remedial measure under investigation and not due to some external factor or chance. To overcome this, before-and-after studies, in particular, should use where possible 'control' groups in addition to 'test' groups of sites or persons. In road safety, it is only in recent years that this has become fully appreciated. In his wide-ranging review of the cost-effectiveness of road safety measures, Trilling[11] stresses the 'inevitable subjectivity' still involved; and in his earlier study, Smeed[12] drew attention to the large margins of error in the estimation of a potential benefit. Despite such frequent difficulties, the available research does generally provide a deeper understanding and better guidance than an approach based upon intuition or commonsense; in road safety, these can prove too easily to be both misleading and expensive.

Financial considerations

There has been a growing emphasis in a number of developed countries upon obtaining value for money from road safety expenditure. Clearly, with their lower gross national product, this must also be a major consideration for developing countries. In recent years, broad reviews of this aspect of road safety have been made by Sabey[13] in the U.K. and by Trilling[11] in the U.S. (referred to in the preceding paragraph). Both studies have examined the full range of road safety countermeasures. Using various individual or subgroupings of countermeasure, they have attempted to evaluate the potential of each for further reducing accidents in their country and the cost of each in achieving this. Trilling regarded his study mainly as the development of a cost-effectiveness methodology in road safety in view of the uncertainties still surrounding such estimates (see above). His study does, however, strongly suggest that there are very wide variations in cost-effectiveness between different types of countermeasures. Particularly striking is the estimate that mandatory seatbelt wearing would only cost the U.S. $500 (1975) for each fatality forestalled. Sabey also highlights certain remedial measures with potentially high rates of return for U.K. conditions; these include mandatory seatbelt wearing, new legislation and publicity against drinking and driving, and low-cost engineering measures.

There has been increasing evidence from the U.K. and the U.S. that relatively detailed local accident investigation, combined with low-cost engineering remedial measures, can be highly cost-effective. The experience being gained from following this approach in these two countries is of particular relevance to the Third World.

Jorgensen and Westat[14] were among the first to point out the relatively high benefit-cost ratios that could be obtained from spot improvements as compared with continuous widening or overall modernisation projects. The limited data available to them strongly suggested that low-cost projects yield the greatest safety benefit per dollar expended. In the U.K., Duff[15] showed a similar result and his analysis of 29 schemes confirmed that small inexpensive schemes could have a very marked effect on road safety.

Table IV compares the cost-effectiveness of a limited selection of countermeasures from five studies. The comparison is restricted to those projects where it appears that only one countermeasure was involved. Although the three sets of data from the U.K. are based on relatively small samples they show similar results to those studies conducted in the U.S., confirming that certain low-cost remedial measures such as road-markings, signing, delineation and improved skid-resistance can be highly cost-effective in reducing accidents.

To the authors' knowledge, the analysis by Asogwa is the only published before-and-after study that has evaluated the safety benefits of countermeasures implemented in developing countries. A more indirect technique was used by Jacobs[16]: personal-injury accident rates in Kenya and Jamaica were correlated with certain geometric design characteristics of rural roads. A

Table IV. A comparison between five studies of the cost-effectiveness/benefit of certain engineering countermeasures

	Duff[16] (U.K.) Av. benefit/ cost ratio	Wilson[17] (Hertfordshire) Av. 1st year rate of return	Landles[18] (London) 'Typical' 1st year rate of return	Henry[19] (California) Cost ($) per accident saved	Jorgensen[20] (U.S.) Av. benefit/ cost ratios
Road-markings, inc. ghost islands	58 *(6)*	1 500% *(5)*	[640% *(60)*] ‡		26·5 *(2 000)**
Shoulder widening					28·8 *(46)*
Road-signs	47 *(2)*	1 500% *(2)*	3 700% *(20)*	350 *(77)*	15·0 *(775)*†
Parking restrictions			2 500% *(20)*		
Traffic management (roundabouts, one-way, etc.)			790% *(40)*		
Pedestrian facilities			320% *(80)*		
Road surface treatment	14 *(1)*	300% *(20)*	200% *(190)*	5 200 *(179)*	20·1 *(96)*
Roundabout installation		350% *(6)*			
Traffic signals (installed or improved)	0·9 *(3)*	−3 700% *(2)*	400% *(140)*	14 800 *(262)*	6·4 *(700)*
Visibility improved	1·1 *(2)*	290% *(2)*			3·0 *(140)*
Channelisation	0·5 *(3)*		[640% *(60)*] ‡	21 000 *(166)*	3·9 *(610)*
Reconstruction				33 300 *(161)*	

Number of projects on which each evaluation is based is shown in italics

* Installation of striping and/or delineators

† In addition 3 046 projects 'Signing and/or marking' with average B/C ratio of 14·9

‡ Hatch-marking, ghost islands and physical channelisation are grouped together

multiple regression analysis showed that lower accident rates were associated with wider roads, fewer junctions per kilometre and higher standards of horizontal curvature. However, it is clearly more sensible first to attempt to improve highway accident rates by low-cost techniques such as improved signing, edgemarking, delineators and central white lines before resorting to widening roads and improving horizontal geometry.

It is also important that safety features, such as those involving geometry, signing and delineation, be introduced at the design stage rather than be added later, almost as an 'afterthought'. For example, it can often be greatly more expensive to widen the main roads at a T-junction after an accident problem has built up than to incorporate it at the construction stage; this is because after construction it is often found that utility services have to be moved for any local widening scheme.

Discussion and conclusions

This paper is based upon a detailed study that has reviewed research into the effectiveness of road safety remedial measures in developed countries and then considered the applicability of the findings of this research to developing countries. The study was primarily intended to establish a list of priorities for a research programme within the TRRL's Overseas Unit. It will be noted that this is a rather different objective from establishing a list of priorities for road safety programmes in developing countries; for example, the review might have identified certain countermeasures that could be regarded as fully researched in developed countries and fully transferable, so that they could be adopted with full confidence in developing countries with little need for additional research. However, the result of the study, briefly summarised in this paper, suggested that it was only with a considerable degree of uncertainty that priority lists for implementation could be drawn up. To summarise again the main reasons for this conclusion:

(*i*) Developed country research has often been less definitive than might be desired.

(*ii*) In addition to physical differences, the major differences in road user attitude and behaviour that are generally found introduce a major element of uncertainty in the potential effectiveness of many countermeasures.

(*iii*) The 'appropriateness' of a countermeasure in terms of technology and cost should also influence priorities.

It is concluded, therefore, that although research findings from developed countries can provide some guidance, the inevitable uncertainties surrounding their transfer to developing countries emphasise the need for caution in their application. As a direct consequence, there is a need to evaluate any countermeasures that are undertaken, thus emphasising the value of mounting local or regional trials of any countermeasures and carefully monitoring their effectiveness before using them nationally.

As far as developing countries are concerned, perhaps the most important finding from research in developed countries is that, on the one hand, it is easy to spend a lot of money to little effect on road safety measures, but, on the other hand, low-cost remedial measures, if properly applied, can yield very high economic returns. These wide variations in cost-effectiveness, taken with the power of local factors to change radically the relative effectiveness of a countermeasure, point again to the need for developing countries to evaluate as fully as possible whatever countermeasures they adopt. This then indicates the further and fundamental need for a good accident data collection analysis system. This should be sufficient to produce essential information for accident investigation purposes, such as accident black-spot maps, but at the same time it should not be too sophisticated either for the needs or abilities of those needed to operate or contribute to it.

With these various goals in mind, the Overseas Unit of the TRRL and the Egyptian Ministries of Interior and Transport have begun a programme of co-operative road safety research, involving the following components:

(*i*) *Police Accident Booklet Design.* An experiment has been conducted that compared four designs of police accident booklet, including one depending heavily upon symbols and pictograms. From the results, two compromise designs were drawn up and are now under trial with four police divisions. In this research, the aim has been to optimise the ease, speed and accuracy with which the booklets can be completed, whilst at the same time ensuring that sufficient details are recorded for the purposes of accident analysis.

(*ii*) *Microcomputer Analysis.* An experimental low-cost microcomputer system is planned to be developed and tested, again with an emphasis on ease of use.

(*iii*) *Accident Investigation.* This work follows broadly the 'Local Authority' approach to accident investigation, as described in the *Accident Investigation Manual*[21] and the *Guidelines for accident reduction and prevention in highway engineering*[22]. The analysis has begun on the two Cairo-Alexandria roads, one of them having a particularly heavy accident rate. A simple accident code number system was adopted and tables of accidents by kilometerage from Cairo drawn up. Accidents at several black-spots have been analysed in some depth using the 'stick diagram' technique. Not unexpectedly, marked differences in the nature of accidents have been found with different sites. Following these analyses, it is planned to introduce low-cost countermeasures and to evaluate their effectiveness.

The Overseas Unit of TRRL would welcome information on any quantitative evaluation of road safety countermeasures, whether local or national, that is carried out in Developing Countries.

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